09/929 696 CO

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent No.	:	6, 918,937	Confirmation No. 8858
Inventors	:	Gilmore et al.	
Issued	:	July 19, 2005	
Title	:	Abrasive Polishing Composition	
Examiner	:	Michael A. Marcheschi	
Customer No.	:	28289	

Certificate
JAN 17 2006
of Correction

REQUEST FOR CERTIFICATE OF CORRECTION OF PATENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

ATTENTION: Decision and Certificate of Correction
Branch of the Patent Issue Division

Sir:

In accordance with 35 U.S.C. §§254 and 255, we attach hereto Form PTO/SB/44 and a copy of proof of errors and request that a Certificate of Correction be issued in the above-identified patent. The following errors appear in the patent as printed:

(1) (Column 5, Line 1, "is an illustrates" should read -- is an illustration --
(See Supp. Preliminary Amendment, filed January 31, 2002, page 6, ¶ 29, line 1)

(2) Column 5, Line 3, "selected area" should read -- selected areas --
(See Supp. Preliminary Amendment, filed January 31, 2002, page 6, ¶ 29, line 2)

(3) Column 15, Line 22, "simpler and demanding" should read -- simpler and **less** demanding --
(See specification at page 22, line 31.)

(4) Column 19, Line 5, "relative notion drive" should read -- relative motion drive --
(See specification at page 28, line 27.)

(5) Column 21, Line 4, "silica, gamet" should read -- silica, garnet --
(See specification at page 31, line 30.)

(6) Column 23, Line 23, "p article size" should read -- particle size --
(See specification at page 35, line 11.)

(7) Column 24, Line 47 of Claim 1, "said medium; an" should read -- said medium; **D.** an --
(See Amendment of January 28, 2005, page 3, Claim 20, line 5. Claim 20 issued as Claim 1.)

JAN 19 2006

The errors numbered 3, 4, 6 and 7 are obvious typographical errors made by Applicants. A check for $100.00 is attached to cover the fee for correction of Applicants' mistakes. The remaining errors are printing errors.

Respectfully submitted,
THE WEBB LAW FIRM

By _____

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PTO/SB/44 (04-05)
Approved for use through 04/30/2007. OMB 0651-0033
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

(Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO.	:	6,918,937
APPLICATION NO.	:	09/929,696
ISSUE DATE	:	July 19, 2005
INVENTORS	:	Gilmore et al.

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

(1) Column 5, Line 1, "is an illustrates" should read -- is an illustration --

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MAILING ADDRESS OF SENDER: The Webb Law Firm
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JAN 19 2006

PATENT APPLICATION
Serial No. 09/929,696
Attorney Docket No. 3580-011343

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of :

James R. GILMORE et al. :

Serial No. 09/929,696 :

Filed August 14, 2001 :

ABRASIVE POLISHING COMPOSITION

Pittsburgh, Pennsylvania
January 31, 2002

Commissioner for Patents
Washington, D.C. 20231

SUPPLEMENTAL PRELIMINARY AMENDMENT

Sir:

Prior to initial examination, Applicants hereby submit a second substitute specification. Two specifications are enclosed, one with revisions marks showing the changes made, and a second specification wherein the changes have been incorporated. Please note that paragraph numbers and paragraph indentation have been added to, while line numbering has been eliminated from, the original specification and revision marks were not used to highlight these changes.

The changes made in the second substitute specification are to correct spelling and grammatical inaccuracies. No new matter has been added in this second substitute specification.

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to Commissioner for Patents, Washington, D.C. 20231 on January 31, 2002.

Nancy Eash
(Name of Person Mailing Paper)

Signature 1/31/2002
Date

The claims and the abstract have not been changed and, therefore, have not been included in the substitute specification.

Examination and allowance of claims 20-22 are respectfully requested.

Respectfully submitted,

WEBB ZIESENHEIM LOGSDON
ORKIN & HANSON, P.C.

By _____

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ABRASIVE POLISHING COMPOSITION

RELATED APPLICATIONS

[0001] This application is a divisional of U.S. Patent application, Serial No. 09/376,892 filed August 18, 1999 which is a continuation in part of U.S. Patent application, Serial No. 09/139,642 filed August 26, 1998, now abandoned.

E.A.

now U.S. Pat. No. 6,273,787

FIELD OF THE INVENTION

[0002] The present invention relates to apparatus and methods for performing abrasive work on a work piece using an abrasive visco-elastic medium and, in particular, to apparatus and methods that impart a relative cyclic motion between the work piece and the medium to provide a separation between the medium and work piece during each cycle which separation is occupied by a fluid having a viscosity less than that of the visco-elastic medium and where the deformation of the medium is between 50 and 99%.

BACKGROUND

TECHNICAL FIELD

[0003] The present invention relates to the technical field of machining and particularly to the field of non-traditional machining processes and equipment employing the techniques of and compositions for abrasive flow machining, grinding, deburring, radiussing, leveling and polishing of work pieces. Such processes are typically employed in the working of castings, forged parts, machined parts, and the like. Most often metal parts and the like. The present invention particularly relates to such operations where the flow is attained by relative motion, preferably orbital motion, between the work piece and the abrasive medium.

PRIOR ART

[0004] Abrasive flow machining has gained wide acceptance for a number of applications as the machining and finishing technique of choice. Such techniques are particularly adapted, for example, to working interior passages in work pieces, for light grinding, deburring, radiussing leveling and polishing of complex surfaces, and particularly three-dimensioned surfaces where surface detail requires working, and in repetitive working of multiple work pieces of complex form and shape.

[0005] In its simplest form, abrasive flow machining requires passing a visco-elastic medium containing an abrasive across the surfaces to be worked. The visco-elastic medium

[0026] Compared to the fluid or plastic extrusion flow which is the basis of U.S. Patent No. 5,125,191, the working rates of the elastic deformation of the present invention are both quite rapid and quite fine, permitting the removal of substantial stock and the attainment of a highly polished surface, in many cases in a single operation with a single medium. Where considerable reduction in roughness is required, it is simple to employ a "roughing" medium followed by a second operation with a "finishing" medium of finer abrasive grit. Rarely will there be occasion to employ more than two media, even to attain the finest surfaces and surface detail and resolution. There is no requirement for sealing the "chamber" in which the operation is performed, and a displacer is optional for a great many forms of work piece, and required only for more complex shapes. In addition, because of the elastic behavior of the medium, the conformate requirements of the displacer, if needed at all, are far less demanding than in our prior work.

[0027] Other advantages of the present invention will become apparent from a perusal of the following detailed description of presently preferred embodiments taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Figure 1 is a stylized, schematic cross section through the apparatus and an associated work piece which illustrates the elements and arrangements of the present invention;

[0029] Figure 2 is an illustration of the orbital relative rotation between the drive and medium providing the separation between the selected areas of the work piece; and

[0030] Figure 3 a-d depicts an orbital cycle of the apparatus shown in Figure 1.

DETAILED DESCRIPTION

[0031] The present invention performs work on surfaces of work pieces to effect light grinding, deburring, radiussing, leveling and polishing of complex surfaces, and particularly three-dimensioned surfaces where surface detail requires such working and in repetitive working of multiple work pieces of complex form and shape.

[0032] Referring to Figure 1, the apparatus of the present invention is represented schematically in an illustrative cross section. In Figure 1, a work piece (1) is mounted on a fixture (2) which is the working element of a relative motion drive mechanism, the details of which are not shown. Fixture (2) is driven, as illustrated in an orbital motion (3a) on which is superimposed a linear reciprocal motion (3b). The linear motion (3b) serves to advance and

TITLE

ABRASIVE POLISHING COMPOSITION

RELATED APPLICATIONS

This application is a divisional of U.S. Patent application, Serial No. 09/376,892 filed August 18, 1999 which is a continuation in part of U.S. Patent application, Serial No. 09/139,642 filed August 26, 1998, now abandoned.

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PRIOR ART

Abrasive flow machining has gained wide acceptance for a number of applications as the machining and finishing technique of choice. Such techniques are particularly adapted, for example, to working interior passages in work pieces, for light grinding, deburring, radiussing leveling and polishing of complex surfaces, and particularly three-dimensioned surfaces where surface detail requires working, and in repetitive working of multiple work pieces of complex form and shape.

plastic flow to provide for conformation of the medium to the surface of the work piece, to provide folding of abrasion debris from the surface into the medium and away from the medium /work piece interface, and to provide the movement of the abrasive within the medium to assure that worn abrasive is removed and fresh abrasive is presented to the working interface.

Operation of the system causes heating of the media during operation. We prefer to take appropriate steps to limit the temperature rise in the media to avoid temperature higher than about 140°F preferably avoiding media temperatures above about 130°F. In most cases, it is preferable to employ a recirculating flow of the media into and out of the containment chamber, so that increments of media in the gap are displace and replaced by fresh, cooler media. The net flow additionally adds assurance of a substantially uniform distribution of the media and continuous working contact with all the surfaces of the work piece to be worked.

The system is operated in the containment chamber under applied strain rates such. that at least about 50%, particularly about 50 to 99%, and preferably about 80 to 95%, of the deflection of the medium under the conditions of operation occurs by elastic deformation and is elastically recovered, and less than 50%, particularly about 1 to 50%, preferably about 5 to 20%, of the deflection of the medium occurs by fluid or plastic flow.

The work piece must be engaged by a fixture or tool to place and hold it in conforming contact with the abrasive medium. If the work piece is the driven element of the relative motion drive mechanism, as will often be the most convenient and preferred arrangement, the fixture or tool is preferably a part of the drive mechanism.

While not a requirement of the invention, it is generally effective to provide a mechanism by which the work piece is advanced into the media containment chamber and into its conforming contact with the medium within the chamber from an external mounting station where the work piece is mounted on the fixture or tool. Such an arrangement can greatly facilitate use of the invention by making the mounting and engagement of the work piece faster, simpler and demanding on the machine operator, or in suitable cases permit automation of the operation by such means to permit unattended operation (at least for substantial periods and substantial numbers of parts). In concert, or as an alternative, the

These attributes may be of no consequence to the operation in many cases. In others, it will be appropriate to feed media under pressure into the interface of portions of the surface which do not experience compressive strain to assure a flow of media, to assure localized pressure adequate to maintain conformity of the media to the surface, and to remove old, worn abrasive and replace it with fresh increments of new or less worn abrasive.

It is also possible, and may be desirable in some cases, to "pulse" the work piece away from and back into the interface one or more times, typically in a direction normal to of at least different from the direction(s) of the relative motion, to assure that conforming contact with the media is assured.

Another variation is to alter the nature, direction or plane of the relative motion through the process cycle to alter the orientation of the part and its surfaces relative to the direction or plane of the relative motion. By employing different motions or different work piece orientations to the motion at different times through the process cycle, the work performed on all worked surfaces may be controlled. In the most common cases, the control is effected to assure that the abrasive work is equivalent on all surfaces of the work piece, although there are some cases in which the motion may be employed to attain differential working on different aspects of the work piece.

If a composite motion is employed which is the resultant of two or more distinct forms of relative motion, it is often possible to entirely offset the orientation of the work performed on the work piece.

In some cases, the action of the elastic deformation is sufficiently directional that a reversal of the direction of the relative notion drive is needed to assure reasonably uniform working of the surfaces. Such occasions arise, for example, when an orbital drive is employed on complex shapes which present leading surface and trailing surface aspects. The orbital motion results in contact between the work piece and medium which is substantially tangential, and the leading aspects of the work piece surface receive more work than trailing aspects in such a case. To offset this differential effect, it is typically sufficient to reverse the drive mechanism to the work piece is worked in both directions. Such directional effects do not generally occur with simple shapes.

that would otherwise disrupt the polymer chains in permanent, irreversible fashion characteristic of the polymer degradation of the prior art materials and procedures.

The preferred poly(boro-siloxane) employed in the present invention has a viscosity (η) in the range of about $\eta = 5 \times 10^3$ Centipoise to about $\eta = 5 \times 10^5$ Centipoise.

The elastic bulk modulus, B, of the preferred poly(boro-siloxane) varies inversely with temperature, T, and directly with the rate of deformation, γ.

The particle size of the abrasive should be the smallest size consistent with. the required rate of working, in light of the hardness and roughness of the surface to be worked and the surface finish to be attained. In general terms, the smaller the particle or "grit" size of the abrasive, the smoother the surface attained. The abrasive will most often have a particle size of from as low as about 1 micrometer up to about 1400-1,600 micrometers (about 16 mesh) or even 2,000 micrometers. More commonly, the abrasive grain size will be in the range of from about 2 to about 400 micrometers, and most commonly from about 20 to about 300 micrometers.

The hardness of the abrasive should be the highest value consistent with the cost of the materials and the limitations of the work piece, in light of the hardness of the work piece material to be polished. Cutting operations also typically employ the hardest and fastest cutting abrasive available, within cost-effectiveness limits. As a general rule, the harder the abrasive, the faster and more efficient the polishing operation. Limiting the hardness of the abrasive may cost-effective in some cases, since, typically, the harder the material, the more expensive it is. In addition, the employment of softer abrasives limits the material removal rate, which may be desirable in limited circumstances to facilitate control.

Selection of the abrasive material is not critical in the present invention, and any of the commonly employed materials will be effective. Examples of suitable materials include, for illustration, alumina, silica, garnet, silicon carbide, boron carbide, diamond, and the like. At higher viscosities it may be possible to use tungsten carbide, although its density may pose problems in maintaining effective dispersion in the medium. The reuse of the polishing medium permits economic use of harder, but more expensive abrasives, with resulting

First and foremost, the present invention is far less dependent on the particle size of the abrasive to attain a specific level of finish. The surface finish in lapping is a direct function of particle size and processing time. In the present invention, the surface finish is reduced by about one order of magnitude for a given abrasive particle size. While the improvement is not fully characterized, and we have no wish to be bound by any theoretical hypotheses, it appears that the improved surface finish is related to the high speed and to the resiliency of the abrasive medium, which both serve to limit the depth of cutting of each abrasive particle in contact with the work piece surface. In lapping, by contrast, the abrasive particles are directly and mechanically driven across the work piece surface, maximizing the depth of cut for the particular p article size.

In addition, the present invention is free of lay in the working pattern on the work piece surface. Lapping typically produces a surface lay representative of the pattern of motion of the tool which drives the abrasive particles. Indeed, the lay produced in lapping is often employed to develop ornamental patterns on work piece surfaces. In the present invention, we believe, although again we have no wish to be bound thereby, that the combination of resilience in the abrasive medium, the plastic flow of the medium and the lack of any bridging between the work piece and any other element in the system result in random or quasi-random working motions of the particles across the work piece surface, precluding the development of any significant lay or patterning on the surface and operating to remove patterns or lay in the surface as introduced by prior operations. Bridging is, of course, a primary feature of lapping operations.

Example 1:

The a R_a apparatus illustrated in Figure 1 was employed to polish a plurality of coinage dies forged of tool steel and engraved with a design, and having a surface roughness as received of 25 micro-inches, R_a. The design was masked by filling with an epoxy resin, and the remaining surfaces of the dies were polished first for twelve minutes using a poly(boro-slioxane) based media filled with 25 mm boron carbide abrasive, followed by a sixteen minute polishing operation with a second media formulation of the poly(boro-siloxane) filled with 2mm diamond abrasive. No displacer was employed. The apparatus employed an orbital

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.	:	09/929,696
Applicant	:	James R. Gilmore et al.
Filed	:	August 14, 2001
Title	:	Abrasive Polishing Composition
Group Art Unit	:	1755
Examiner	:	Michael A. Marcheschi

Mail Stop Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT

Sir:

In response to the Office Action dated July 29, 2004, please amend the above-identified patent application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims begin on page 3 of this paper.

Remarks begin on page 4 of this paper.

A three-month **Petition for Extension of Time** accompanies this Amendment.

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on January 28, 2005.

Kimberly N. Welday
(Name of Person Mailing Paper)

Kimberly N. Welday 01/28/2005
Signature Date

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

Listing of Claims:

(1) ~~20.~~ (Currently Amended): A rheopectic abrasive visco-elastic medium composition for abrasive working of a work piece comprising: A. a visco-elastic poly(boro-siloxane) polymer carrier having a static viscosity of from about $\eta = 5 \times 10^3$ Centipoise to about $\eta = 5 \times 10^5$ Centipoise; B. a particulate abrasive; C. an optional inert filler in an amount of up to about 25% by weight of said medium; an optional plasticizing lubricant for said visco-elastic polymer in an amount of up to about 25% by weight of said medium; E. said medium having a static viscosity of from about $\eta = 2 \times 10^4$ Centipoise to about $\eta = 8 \times 10^6$ Centipoise, said medium containing a total volume of said particulate abrasive and of said inert filler ~~is~~ less than a ~~the~~ critical particulate solids volume concentration of said medium; and F. the~~said~~ resulting visco-elastic abrasive medium having from 50% to about 99% of the deflection by elastic deformation, and 1 to 50% of the deflection of the medium by fluid or plastic flow, when subjected to applied strain rates greater than about 2.5 sec^{-1}.

(2) ~~21.~~ (Currently Amended): The medium composition of Claim ~~20~~ 1 wherein said ~~visco-elastic~~ particulate abrasive comprises ~~is a~~ material selected from the group consisting of alumina, silica, garnet, silicon carbide, diamond, tungsten carbide and mixtures thereof.

(3) ~~22.~~ (Currently Amended): The medium composition of claim ~~20~~ 1 wherein said particulate abrasive further comprises particles which range from about 1 to about 2000 micrometers in their greatest dimension.